

Support Tools for I&M Decision-making: Moving from the Ideal to the Real

By June C. Rugh and David L. Peterson

Editor's Note: This article (the second in a series of two) represents a research effort on the part of the Pacific Northwest Region to offer an approach for developing a dynamic, technically rigorous inventory & monitoring program within each park. Based on state-of-the-art methods and analyses, it offers practical strategy and support tools that will facilitate I&M program development among parks.

With the help of the interdisciplinary planning team described in the previous article (*Park Science*, Fall 1992), most parks will be able to develop a broad inventory and monitoring (I&M) "ideal" plan that encompasses a diversity of projects. However budgetary and personnel constraints mean that decisions must be made about the relative value and feasibility of various projects within the overall plan. This is a complex process involving a wide range of issues and hundreds of individual decisions; lacking a systematic approach, many of those decisions may be made with limited knowledge or by intuition alone. The support tools discussed here--the Analytic Hierarchy Process and supporting software, Expert Choice1--are the core of a new analytical framework for I&M planning, providing both strategic and technical support for resource managers.

The Analytic Hierarchy Process (AHP) is a structured approach to decision-making that allows resource managers to incorporate a large number of criteria and judgments including those based on experiential knowledge or intuition. Decision-makers are able to weigh the contributions of each option and arrive at a final assessment (or priority) that is both consistent and defensible. Applied to I&M program development, this approach focuses on three specific steps: (1) Identify I&M projects; (2) Prioritize projects; and (3) Maximize total I&M program value over all projects.

First, decision-makers identify potential I&M projects that would fulfill program objectives. Second, these projects are prioritized based on their total contribution to the I&M program goals. AHP is used as a systematic technique to determine those priorities, which represent the definable value each project brings to the program as a whole. Third, budget and personnel limitations are worked into program planning in order to maximize the total I&M program value over all implemented projects.

Park personnel need not be familiar with the technical details of the AHP and related software; the regional I&M coordinator would operate the software, working with resource managers to derive model inputs and evaluate model outputs. However some conceptual background can clarify AHP's role in I&M planning. The principal ideas of AHP are (1) the use of hierarchies to structure decision-making, and (2) the application of judgement measures and formal mathematics to express and quantify individual preferences.

As a basic paradigm, the hierarchy is par-

ticularly useful because it is stable, resisting disruptions; it accommodates additions easily; its components can be arranged in a modular fashion, allowing efficient modifications, and finally, the hierarchy is capable of incorporating a large number of elements economically.

To construct a hierarchy, a primary goal is placed at the top. For example, the goal in Figure 2 is to choose the most desirable car; the criteria for this decision are initial cost, maintenance costs, fuel costs, resale value, status, comfort, and reliability. (Additional tiers of subcriteria would be added in a more involved case.) Alternatives are the actual car models being considered and compared: VW, Honda, Chevy, and Cadillac.

Pairwise comparisons among hierarchy elements at any level provide a ratio scale ranking of these elements. First, the main criteria are compared with respect to the goal. Here, personal judgment comes into play; the decision-maker enters judgments as to the relative value of initial cost vs. maintenance costs, initial cost vs. resale value, and so on. Thus, the initial cost might be judged to be moderately more important than maintenance costs.

The next step is to compare the alternatives with respect to each criterion; the user records judgments for VW vs. Honda with respect to initial cost, and so forth. Throughout this process, the more subjective elements such as intuition, experience, or personal preference

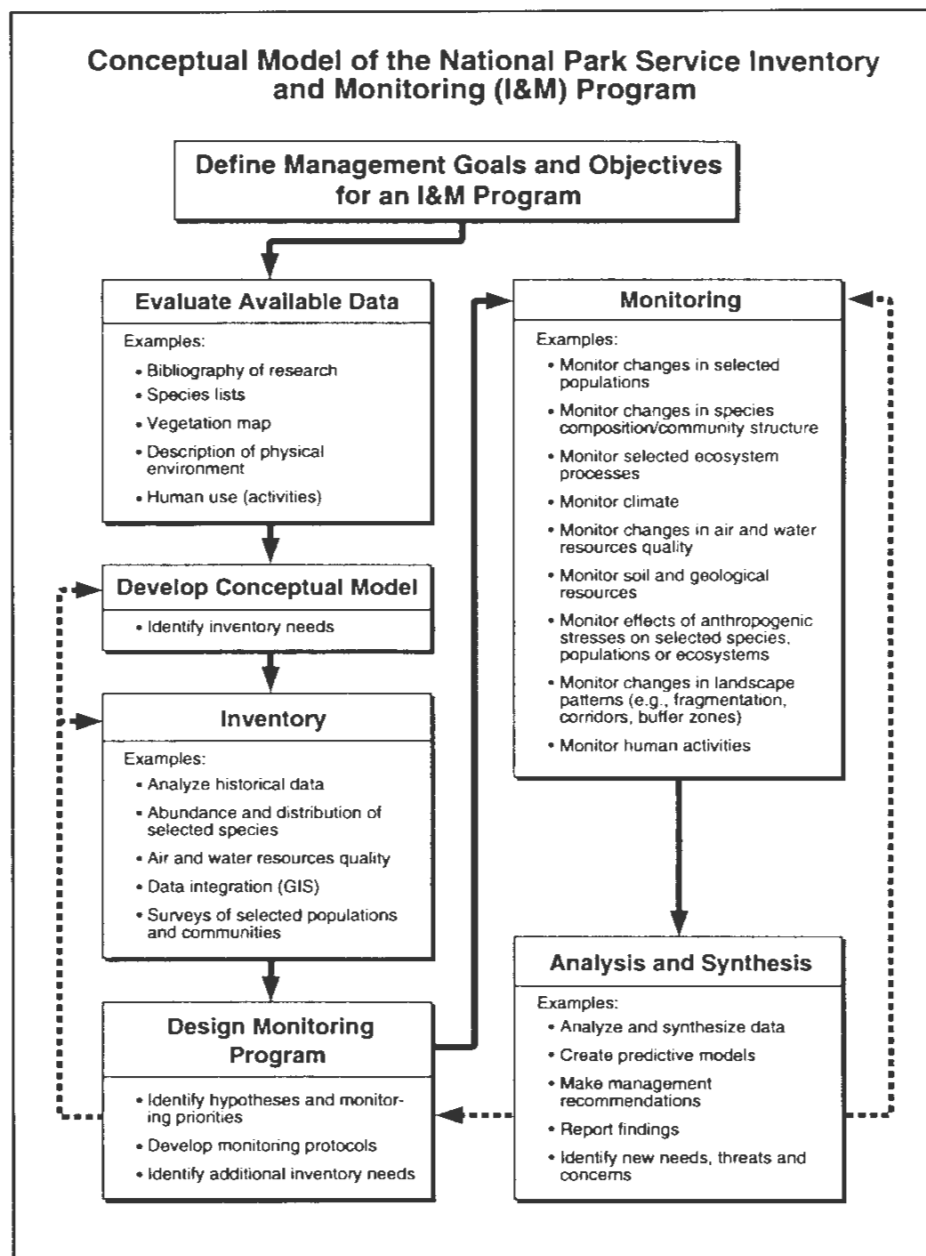


Figure 1 Conceptual overview of the inventory and monitoring process in natural park areas.

are as systematically quantified as objective factors such as cost. With sets of these pairwise comparisons, a ratio scale emerges that captures the priority of the related elements with respect to the comparison criteria.

Further options, such as combining judgments concerning several criteria, are available as well. Figure 3 illustrates the AHP as applied to the process of rating I&M projects.

When applied to I&M planning, AHP would enable managers to define criteria for priorities in a straightforward yet versatile way. For example, priorities may be set for part of an I&M plan based on economic and biological factors. The biological factors may be subdivided into several subfactors, such as endangered species status, susceptibility to air pollution, and geographic distribution. Each of these subfactors can be further divided into yet another set of subfactors for a finer resolution. This hierarchical process can continue for many levels to include all possibilities that should be considered, with rankings assigned to each level of the process.

The linkages become complex after only a few levels and cannot be tracked efficiently with pencil and paper. For this reason, AHP has been incorporated in the software package Expert Choice¹. This software allows the user to apply

hundreds of qualitative and quantitative assessments simultaneously to establish linkages and calculate final priority rankings quickly and accurately. It also enables a resource manager to explore the nature of decisions used in the I&M planning process.

The knowledge database created can be changed or updated at any time, making it an exemplary tool for I&M decision-making. Moreover, the model can accommodate any agenda the park might wish to include. This is particularly pertinent to resource management planning by federal agencies, which often requires consideration of political issues.

Most important, AHP/EC does not *make* decisions for managers, but instead *facilitates* the process of decision-making. By providing a framework in which I&M and resource management planning issues can be addressed and quantified explicitly, these tools offer resource managers unprecedented decision-making power, versatility, and accountability.

When allocating resources within I&M program planning, the goal is to do the most I&M work possible within established budget and personnel limitations, with "most" defined as the greatest total program value. This means that an individual project's value to the program alone can determine the most effective

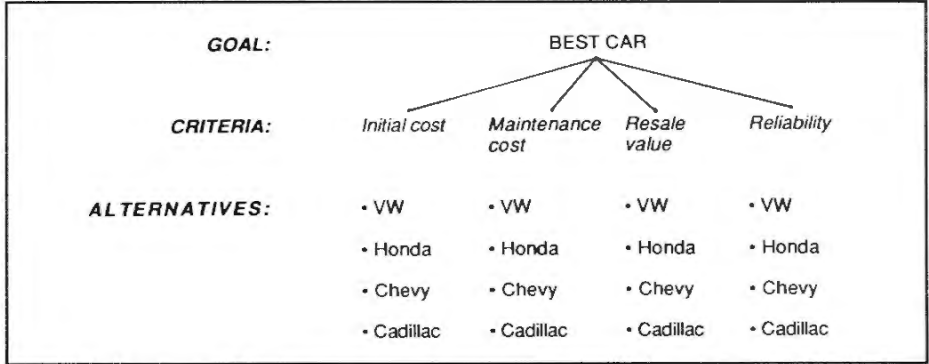


Figure 2. Choosing the Best Car: An illustration of the Analytical Hierarchy Process

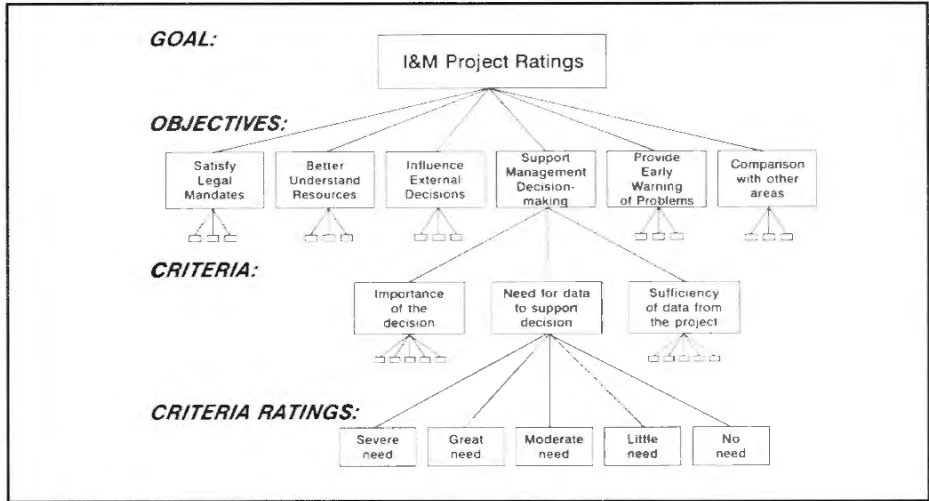


Figure 3 Rating I & M projects using the Analytical Hierarchy Process

allocation of resources. Similarly, a cost-benefit approach--wherein projects with the best economic payoff garner the highest rankings--falls short by not including other constraints, such as personnel time.

Schmoldt et al. (1992) have formulated an integer programming model which, by combining AHP and linear programming, maximizes total program value, subject to specified constraints. With technical support from the I&M team, resource managers would enter the minimum constraints (budget and personnel limitations) into the mathematical formulation. Other constraints, such as restrictions on project timing, could be factored in as well. For example, if a particular project to analyze snow chemistry should not be performed until a geographic survey of snow has been completed, then those constraints would be added to the formulation.

As the final step in the resource allocation process, priority values estimated from the AHP exercise would be used as coefficients in the integer programming model.

As in any optimization procedure, the results of this "constrained optimization" approach will be only as realistic as the parameter values used in the calculations. More accurate budget or personnel estimates, or revised value judgments, can alter the emerging I&M program. Repeated use of this process will insure that results are acceptable and stable.

¹ Tradenames are used for information purposes only. No endorsement by the U.S. Department of the Interior is implied.

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The following publications are available from the NPS CPSU, AR-10, U/WA, Seattle, WA 98195:

- Peterson, D.L., D.G. Silsbee, and D.L. Schmoldt. 1992. Guidelines for developing inventory and monitoring plans in national parks. Manuscript submitted for publication.
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- Silsbee, D.G., and D.L. Peterson. 1992. Planning and implementation of long-term resource monitoring programs. Environmental Monitoring and Assessment (in press).
- Silsbee, D.G., and D.L. Peterson. 1991. Designing and implementing comprehensive long-term inventory and monitoring programs for NP System lands. Natural Resources. Rep. NRR-91/04. National Park Service, Denver, CO.